PM 2000.097

APPLICATION FOR

UNITED STATES LETTERS PATENT

TITLE: **NONSTRUCTURAL BUOYANCY CAN**

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"EXPRESS MAIL" Label No.: ET608077364US
Date of Deposit: February 01, 2002

NONSTRUCTURAL BUOYANCY CAN

[0001] This application claims the benefit of U.S. Provisional Application No. 60/266,583 filed February 5, 2001.

FIELD OF THE INVENTION

[0002] The invention relates to device used to provide tension for a riser in an offshore drilling and/or production apparatus.

BACKGROUND

[0003] More than two-thirds of the Earth is covered by oceans. As the petroleum industry continues in its search for hydrocarbons, it is finding that more and more of the untapped hydrocarbon reservoirs are located beneath the oceans, in "offshore" reservoirs. A typical system used to obtain and produce hydrocarbons from offshore reservoirs comprises a host floating vessel located on the surface of the ocean, hydrocarbon producing wells located on the ocean floor and a conduit used for drilling or hydrocarbon recovery that connects the wells to the host floating vessel. This conduit is commonly referred to as a riser.

[0004] In operation, risers in these offshore systems need to be maintained in tension to avoid buckling or other failures. A common method used by the petroleum industry for maintaining this tension is by attaching buoyancy chambers near the tops of the risers. However, a problem encountered by the industry has been the high costs associated with manufacturing a suitable housing for the buoyancy chambers that can withstand the various loads acting upon it in the offshore environment. For example, movement of the host floating platform and wave/current forces cause the riser and buoyancy chamber housings to bend. In addition, if the riser and buoyancy system is

laterally supported, contact between the buoyancy chamber housings and the lateral support points causes localized bending in the housings. Accordingly, a significant amount of structural steel must be added to the buoyancy chamber housing to resist these loads. Since these loads are also dynamic in nature, expensive fatigue resistant connections are often required. The increase in the amount of material for the housing and the added complexity of fabrication result in increased costs. Moreover, the weight of the additional steel requires additional buoyancy, i.e. a larger buoyancy chamber, which further requires additional material and costs.

[0005] Another problem encountered by the industry is the high bending stresses that occur at the connections between individual buoyancy chambers due to stiffness discontinuity. This stiffness discontinuity is caused mainly by the relatively large difference between the radial dimensions of the buoyancy chambers and the connector element between the buoyancy chambers. Because of these high bending stresses, heavy and relatively complex connection elements are required, however, overall system reliability might be reduced.

SUMMARY OF THE INVENTION

[0006] A buoyancy apparatus for providing tension to an offshore riser that comprises at least one buoyancy element and a frame that comprises a plurality of vertical members externally disposed to the buoyancy element, and a plurality of connectors securing the vertical members to the riser.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG 1. is an elevational view of a floating platform in accordance with a conventional riser / buoyancy system.

[0008] FIG 2. is a perspective view of a conventional buoyancy can.

[0009] FIG 3. is a perspective view of an embodiment of a buoyancy element that may be used in accordance with the present invention.

[0010] FIG 4. is a perspective view of an embodiment of the buoyancy system in accordance with the present invention.

[0011] FIGS 5a and 5b. are perspective views of embodiments of the buoyancy system in accordance with the present invention, wherein the frame had additional internal connectors.

[0012] FIG. 6. is a perspective view of an embodiment of the buoyancy system in accordance with the present invention, with a frame containing arched bracing members.

[0013] FIG 7. is a perspective view of an embodiment of the buoyancy system in accordance with the present invention, shown in relation to contact with a riser guide.

DETAILED DESCRIPTION OF THE INVENTION

[0014] A typical offshore riser system is shown in Fig. 1. Riser 15 passes through a moonpool within the floating host facility (only the lower portion of the host facility indicated), and connects to the subsea reservoir. The riser 15 is maintained in tension by a series of buoyancy elements, shown in Fig. 1 as buoyancy cans 100, which are connected to a stem pipe 25. As is known to those in the relevant art, a stem pipe is a cylindrical pipe that concentrically surrounds a riser and is attached to the riser near the riser's top, thereby transferring buoyancy from the buoyancy cans to the riser. Riser guides 70 provide lateral support for the riser/buoyancy system by allowing free vertical motion of the riser/buoyancy can configuration within the host facility, while restricting its lateral movements. When in operation, the buoyancy cans 100 can be directly subjected to loads caused by movement of the host facility and wave and current action. Moreover, high bending stresses can occur at the connections between individual buoyancy cans due to stiffness discontinuity at these locations. Accordingly, these cans 100 are typically constructed with an additional amount of structural steel 20, as indicated in Fig. 2, to provide it with the necessary strength and durability to withstand the loads.

[0015] The current invention is a riser-tensioning device that comprises a buoyancy element and a frame enclosing the buoyancy element. The frame is secured directly to the riser, or indirectly to the riser through a riser stem pipe, and allows buoyancy to be transferred by the buoyancy element through the frame and to the riser. The frame can be constructed so that it is neutrally or positively buoyant in water, and therefore the weight of the frame does not counteract the buoyancy provided by the buoyancy element. The frame accepts external loads that would otherwise act upon the buoyancy element. The buoyancy element can therefore be made with fewer structural requirements, and can be made of lighter materials, which may lead to reduced size and reduced manufacturing and materials costs. The buoyancy element may comprise any suitable buoyancy device or devices used in the offshore petroleum industry to provide buoyancy to a riser, including but not limited to buoyancy chambers (i.e. buoyancy cans) and syntactic foams.

[0016] An embodiment of the buoyancy system of the present invention is described in Figs. 3 and 4. As provided in Fig. 3, the buoyancy element in this embodiment is a buoyancy can which comprises a housing 65 with an outer shell 150 and an inner shell 155 concentrically positioned within, thereby forming an annulus between the outer and inner shells. Inner shell 155 may be comprised of stem pipe 25, as is indicated in Fig. 3. However, use of a stem pipe 25 is not required, as will be explained later, and inner shell 155 may comprise riser 15 if no stem pipe is used. Flange 82 may be present on the ends of stem pipe 25 to provide connection points for adjacent stem pipes 25, which may be desirable when using multiple buoyancy elements as will be explained later. The annulus is closed at the top 185 to form buoyancy chamber 165. The annulus may be open or closed at the bottom 175 of the buoyancy chamber 165. The buoyancy chamber 165 is filled or depleted of air or other gases using air service lines 90 to provide the desired buoyancy. The buoyancy chamber housing 65 may contain internal or external steel bracing 20, such as shown in Fig. 2, to provide additional structural support, but may also be constructed without such additional structural elements, as indicated in Fig. 3. Although this embodiment

describes the buoyancy chamber housing 65 as being cylindrical in shape, the housing 65 is not limited in this manner.

[0017] Referring now to Fig. 4, the external frame 60 is designed and constructed to carry the loads exerted by external forces that would otherwise act on the buoyancy chamber housing 65. As one of ordinary skill in the art can appreciate, the external frame 60 may be designed with various configurations while still accomplishing this load transfer. The present embodiment shows a frame 60 comprised of frame columns 75 disposed vertically along the exterior of the housing 65 and connectors 80, here radial arms located above and below the housing 65, that connect frame columns 75 to the riser stem pipe 25. Although the embodiment disclosed in Fig. 4 shows four vertical frame columns 75, the invention is not intended to be limited as such. Preferably, in this embodiment there will be three or more vertically disposed frame columns 75 comprising frame 60. Other connectors including but not limited to plates or disks may used instead of or in addition to radial arms to secure the frame columns 75 to the riser stem pipe 25.

[0018] Although it is disclosed in this embodiment that the frame 60 is connected to riser 15 through riser stem pipe 25, it should be understood that radial arms 80 can directly connect to the riser 15, without using stem pipe 25.

[0019] Another embodiment of the invention is disclosed in Fig. 5a, where a plurality of connectors 80A – 80E are positioned along the length of the external frame 60. Each connector attaches frame columns 75 to the riser 15, either directly or indirectly, and provides further structural support for the frame. Indirect attachment includes attachment of the connectors to the riser 15 through a stem pipe 25 (as previously noted), as shown in Fig. 5a. Individual buoyancy elements may be positioned in between the connectors, for example, syntactic foam may be positioned between connectors 80A and 80B, between connectors 80B and 80C, and so forth. Alternatively, the buoyancy element or elements may extend through some or all the connectors. Referring again to Fig. 5a, a single buoyancy can 100 extends through three of the plate connectors 80B, 80C and 80D. The three plate connectors 80B –

80D are partially contained within the buoyancy can 100 and contain perforations or other openings 95 that allow air or other fluid to pass therethrough, as fluid communication should be maintained within the buoyancy can 100. The buoyancy can 100 may be constructed in sections, for example sections 65A – 65D. Section 65A is a tubular element having a closed top and an open bottom, and sections 65B - 65D are tubular elements having open tops and open bottoms. Each section may be secured, by welding or other means, to the connector 80 directly above and below the section. Accordingly, the fluid integrity and the buoyancy of the can 100 is maintained. Another similar embodiment discloses extending a buoyancy element through a series of vertically aligned perforations 95 in connectors 80. Referring to Fig. 5b, a buoyancy can 100A can be adapted to pass through a series of vertically aligned perforations 95A in the series of connectors 80. More than one series of vertically aligned perforations, for example perforation series 95B, 95C, and 95D, may be present to receive additional buoyancy elements (shown as buoyancy cans 100B – 100D). Persons skilled in the art will recognize that modifications, alterations, and variations to this invention are possible without departing from the true intent and scope of the invention.

[0020] Referring to Fig. 6, if additional support for the frame 60 is needed, one or more external bracing members 150 connecting the individual frame columns 75 may be provided. These external bracing members 150 may comprise horizontal members, diagonal members, or a combination of horizontal and diagonal members. These bracing members 150 may also be configured to conform to the exterior of the buoyancy element to help improve the load transfer. For example, as shown in Fig. 6, the bracing members 150 may be radially arched to form a ring about a cylindrically shaped buoyancy chamber housing 65.

[0021] It is believed that when in operation, the buoyant force from the buoyancy element will be transferred through external frame 60, which is attached directly or indirectly (if attached through stem pipe 25) to the riser 15. Lateral hydrodynamic loads caused by the motions of the host floating vessel and wave/current action are

reacted at riser guide 70, as shown in Fig. 7, which under the present embodiment interacts with external frame 60 rather than the buoyancy chamber housing 65.

[0022] The frame columns 75 may be constructed of any suitable material that can be selected by one skilled in the art to provide the frame with necessary strength and durability to operate in an offshore environment. Preferably, the frame columns 75 are constructed of hollow members, and more preferably tubular members, and even more preferably the members are sealed such that they are neutrally or positively buoyant in water.

[0023] The buoyancy chamber housing 65 of the described embodiment can be constructed of any appropriate material used in the industry for such buoyancy devices, typically steel. But in addition, it can be constructed of lightweight, flexible and inexpensive material including but not limited to rubber, fiberglass and thin steel. The use of such materials can provide cost savings over previously used materials. Moreover, the use of nonmetallic materials eliminates the need for expensive corrosion protection of the housing. The buoyancy elements useful for this invention are not limited to buoyancy cans. Other buoyancy elements used in the offshore industry, including but not limited to syntactic foams, may be used in conjunction with the frame of this invention and would be obvious to one of ordinary skill in the art.

[0024] Another benefit of the current embodiment is the ability to eliminate unnecessary penetrations in the buoyancy chamber housing for the gas service lines 90. It is undesirable to leave gas service lines 90 unprotected from possible collisions with other objects near the buoyancy can. Accordingly, it is common practice in the industry to introduce gas service lines 90 into the buoyancy chamber 165 through penetrations in the buoyancy chamber housing 65, thereby minimizing exposure to potential collisions. However, in creating these penetrations the buoyancy chamber housing 65 is weakened. As indicated in Fig. 4, the current invention allows the lines 90 to be run along the side of the external frame 60, or within the frame 60 (not shown), thereby protecting the lines 90 from possible collisions. The lines 90 may

enter the buoyancy chamber from an open bottom in the housing 175, or an opening (not shown) in a closed housing bottom 175. This design will improve system reliability and enhance the housing's integrity by eliminating the penetrations in the housing.

[0025] It is common in the industry to use multiple buoyancy elements to provide buoyancy to a riser. The buoyancy elements are typically attached to the riser 15, or riser stem pipe 25, in series with one attached above another, as shown in Fig. 1. For attaching multiple buoyancy elements in series to a riser 15, or a riser stem pipe 25, under the present invention, it is preferred to provide an external frame 60 around each buoyancy element, as disclosed herein, and to attach each external frame 60 to the frame 60 above and below it to provide a continuous frame over each of the buoyancy elements. Frame 60 may contain top mating elements 84 and bottom mating elements 86 to aid in connecting and maintaining the connection between the attached frames 60. For example, mating element 84 of a lower positioned frame 60 can be connectively received by mating element 86 of a higher positioned frame 60. Other mating elements can be used that would be obvious to one of ordinary skill in the art. Mating elements 84 and 86, when connected, preferably maintain a flush connection respect to the exterior of frame columns 75 so as to not interfere with the vertical movement of the frame/buoyancy element configuration in relation to riser guide 70. Flange 82 may be present on either end of stem pipe 25 to provide a connection point for an adjacent stem pipe 25. Each frame 60 is attached to the riser 15, or riser stem pipe 25, in a manner as previously disclosed. In this way, a continuous external frame 60 is provided over all of the buoyancy elements, thereby eliminating stiffness discontinuity along the buoyancy system and its associated disadvantages, i.e. stresses that lead to bending at connections between buoyancy chamber housings.

[0026] The present invention has been described in connection with its preferred embodiments. However persons skilled in the art will recognize that many modifications, alterations, and variations to the invention are possible without

departing from the true scope of the invention. Accordingly, all such modifications, alterations, and variations shall be deemed to be included in this invention, as defined by the appended claims.